RUNOFF CHANGES IN CZECH RIVER BASINS – THE OUTPUTS OF RAINFALL-RUNOFF SIMULATIONS USING DIFFERENT CLIMATE CHANGE SCENARIOS

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Runoff changes have been simulated for several river basins in different geological conditions and for diverse vegetation cover using conceptual model of rainfall-runoff process Sacramento. The catchment areas of basins are mostly in the range of 100 – 500 km². As alternative inputs climatic scenarios UKHI, UKTR and XCCC 2050 have been used and in part of experiments also the incremental scenarios have been applied; moreover, the outputs of stochastic weather generator of daily time series prepared on the base of the ECHAM model has also been used. The main result of simulations is that in the case of increased air temperature the shift in annual runoff cycle would appear.

KEY WORDS: Runoff Changes, Flood Flow Regime, Climate Changes, Climate Scenarios, Sacramento Model.
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Fig. 1. Comparison of variability of flows in annual cycle in basins with different geological conditions and in different periods.

Obr. 1. Porovnání proměnlivosti průtoků v ročním cyklu v povodí s rozdílnými geologickými podmínkami a v různých obdobích.
of course, the consequence of changed vegetation cover and the resulting evapotranspiration change. This rather complex problem is prepared for analyses on global scale in the research project of BAHC/IGBP [2]; simplified preliminary analysis of these phenomena for the given purposes for the Czech territory has been presented in [3] and [4].

Table 1. The largest floods at the Vltava River in Prague during 2 periods: 1890 - 1990 and 1901 - 1980.

<table>
<thead>
<tr>
<th>Period</th>
<th>Datum</th>
<th>$Q_{\text{max}}$ [m$^3$ s$^{-1}$]</th>
<th>Period</th>
<th>Datum</th>
<th>$Q_{\text{max}}$ [m$^3$ s$^{-1}$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890 - 1900 (10 yrs)</td>
<td>4/10 1890</td>
<td>3975</td>
<td>1901 - 1980 (80 yrs)</td>
<td>15/3 1940</td>
<td>3245</td>
</tr>
<tr>
<td>9/4 1900</td>
<td>2770</td>
<td>2 9/7 1954</td>
<td>2920</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/5 1896</td>
<td>2470</td>
<td>3 15/3 1947</td>
<td>2272</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14/9 1899</td>
<td>2130</td>
<td>4 8/10 1915</td>
<td>2100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31/7 1897</td>
<td>2090</td>
<td>5 15/1 1920</td>
<td>2100</td>
<td></td>
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</tr>
</tbody>
</table>

3. Used model and data

As the main tool of runoff simulation the model Sacramento soil moisture accounting (SAC-SMA) has been used [5]. This is the conceptual water balance model with the lumped inputs and parameters, which have been described with more details in [4], where the experiments with this model for the Czech basin were evaluated.

For its calibration the daily time series have been used. The comprehensive evaluation and examples of accuracy of simulations are presented in Tab. 2 and in Figs. 2 and 3, where also some characteristics of basins are provided. A bit surprising is that statistical criteria of accuracy do not depend on the catchment area - see the Tab. 2, despite the large heterogeneity in the great basin of the Elbe River. Even so the results presented in the following parts of paper are only for the basins with relatively homogenous climatic and geomorphological conditions as given in Fig. 3.

As a specific part of accuracy evaluations the Tab. 3 could be considered; it illustrates the sensitivity of simulated flows of the Metuje River to the input changes. There is apparent that the precipitation or evapotranspiration change 5 % is roughly identical with limits of 'noises' included in the input and/or output series.
Results of simulations for different climatic scenarios

Incremental scenarios

As Tab. 3 suggests even a simple "increase" of air temperature would cause important change of river flows. Therefore several attempts with runoff simulations have been prepared which show the range of possible runoff changes and the shift in its annual cycle - see Fig. 4. These examples also demonstrate that it is not decisive whether the increase of air temperature would be variable or constant in round-year cycle for regime of snow deposits, but, for low flows this effect is more important.

The scenarios UKHI, UKTR and XCCC 2050

The range of expected changes of inputs of simulations for the Czech territory is illustrated in Fig. 5. These scenarios have been provided in the framework of cooperation in the research project sponsored by EU, [1]. In Fig. 5 the assumed increase of evapotranspiration is noticeable for the scenario UKTR. The experiments with physically based model BROOK [6] have been carried out, in which evapotranspiration change was tested at the Spulkovo Creek sub-basin in Sumava Mts., near the Austrian-German borders. The intention has been to verify these values, [3].

Several alternative outputs have been prepared with alternative evapotranspiration. The values presented in Fig. 6 are considered as the resulting runoff changes. Similar tendencies in annual cycle are visible for three given scenarios, what is namely apparent in the case of the Metuje River and the Upa River. Different geomorphological conditions probably cause the typical shape of lines in each basin.
Runoff changes in Czech river basins – the outputs of rainfall-runoff simulations

Fig. 5. The scenarios of changed inputs.
Obr. 5. Klimatické scénáře změn srážek, teplot a evapotranspirace.
Simulations using outputs of stochastic weather generator

Daily precipitation and air-temperatures are the input for simulations which are presented in Fig. 7. These inputs follow from scenarios produced by model ECHAM, i.e. for 1 × CO₂ climate. The observed long-term average monthly discharges are compared there with simulations: (i) for base line conditions (ii) for directly modified climate for 2 × CO₂ conditions (iii) using daily series produced by stochastic weather generator. The description of this approach is given in [7] and [8].

Basic features of this scenario are similar with foregoing cases, i.e. the shift in annual cycle of runoff appears also here, but, due omitted role of evapotranspiration change the decrease of flow is not visible. As the main intention of implementation of this scenario is to evaluate the possible effect of redistributed precipitation on flood flows, where the problem of evapotranspiration does not seem to be quite relevant.

5. Conclusions

The increase of air temperature would cause in climatic conditions of the Czech Republic namely the shift in runoff annual cycle. If the change of precipitation would be in the range +5 – 10 % then the water losses in summer – autumn period could not be compensated and discharges would decrease in low flow periods due to reduced groundwater storages. Lower snow deposits and higher frequency of floods during winter and spring period are to be expected.

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Figure 9. Simulations of the large flood using increased and decreased intensity of rainfall - Blanice River.

Obr. 9. Simulace povodne v Husinci na Blanici se zvysenou a snizenou intenzitou srážek.

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ZMĚNY ODTOKU V POVODÍ ČESKÝCH TOKŮ – VÝSTUPY
SRÁŽKO-ODTOKOVÝCH SIMULACÍ S VYUŽITÍM RŮZNÝCH
KLIMATICKÝCH SCÉNÁŘŮ

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Četné dosavadní rozbory a simulace indikují, že možné změny vodního režimu v důsledku předpokládaného klimatického oteplení mohou být natolik významné, že je žádoucí analyzovat jejich případný rozsah a dopady i přestože neexistují dostatečně věrohodné podklady resp. vstupy pro simulace srážko-odtokového procesu pro změněné klimatické poměry.

Analýzy a simulace na základě různých klimatických scénářů kromě toho mohou přispět také k objasnění vlivu existující klimatické variabilitu na výkyvy v režimu povodní a suchých období a zvýšit tak spolehlivost predikcí a ochranu před jejich negativními účinky.

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